Maternal Intrapartum Temperature Elevation as a Risk Factor for Cesarean Delivery and Assisted Vaginal Delivery

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ABSTRACT

Objectives. This study investigated the association of intrapartum temperature elevation with cesarean delivery and assisted vaginal delivery.

Methods. Participants were 1233 nulliparous women with singleton, term pregnancies in vertex presentations who had spontaneous labors and were afebrile (temperature: 99.5°F [37.5°C]) at admission for delivery. Rates of cesarean and assisted vaginal deliveries according to highest intrapartum temperature were examined by epidural status.

Results. Women with maximum intrapartum temperatures higher than 99.5°F were 3 times as likely to experience cesarean (25.2% vs 7.2%) or assisted vaginal delivery (25.2% vs 8.5%). The association was present in epidural users and nonusers and persisted after birthweight, epidural use, and labor length had been controlled. In adjusted analyses, temperature elevation was associated with a doubling in the risk of cesarean delivery (odds ratio [OR] = 2.3, 95% confidence interval [CI] = 1.5, 3.4) and assisted vaginal delivery (OR = 2.1, 95% CI = 1.4, 3.1).

Conclusions. Modest temperature elevation developing during labor was associated with higher rates of cesarean and assisted vaginal deliveries. More frequent temperature elevation among women with epidural analgesia may explain in part the higher rates of cesarean and assisted vaginal deliveries observed with epidural use. (*Am J Public Health.* 1999;89:506–510)

Clinical concern about maternal fever during labor has largely been related to the possibility of infection. Although it has been assumed that fever during labor is usually secondary to infection, a recent study suggested that for women with low-risk full-term pregnancies, much of the fever that develops during labor may not be infectious in origin but rather a consequence of the use of epidural analgesia.[1] A number of studies have demonstrated an increase in maternal temperature or higher rate of fever associated with use of epidural analgesia.[1–6] Epidural analgesia has also been linked to an increased risk of cesarean delivery and assisted vaginal delivery.[7,8] A number of studies have reported that rates of cesarean delivery are at least twice as high in women who have received epidural analgesia as in women not receiving it.[9–13] This higher rate of cesarean deliveries is related specifically to an increase in failure to progress.[13] A higher rate of assisted vaginal delivery has also been consistently reported to be associated with epidural analgesia.[8] Several large studies have shown a 4-fold increase in assisted vaginal delivery associated with epidural use in nulliparous women.[14,15]

We conducted this study to determine whether temperature elevation developing during term labor is a risk factor for cesarean delivery and assisted vaginal delivery and whether the increased occurrence of temperature elevation among women receiving epidural analgesia might be one reason for the higher rates of cesarean delivery and assisted vaginal delivery observed with epidural use.

Methods

The base sample for this study comprised the 1934 nulliparous women enrolled in the active management of labor trial conducted at Brigham and Women's Hospital, Boston, Mass, from May 1990 through October 1994. Approval for the study was obtained from the Human Research Committee of Brigham and Women's Hospital, and all participants provided informed consent. Study participants were low-risk nulliparous women. Women with conditions associated with an increased risk of preterm or cesarean delivery (such as multiple pregnancy, diabetes, cervical incompetence, or pregnancy-induced hypertension) were ineligible. Overall, 64% of eligible women were enrolled in the study. Women enrolling were randomly assigned to have their labor managed under a protocol of active management of labor or were assigned to usual care. The active management of labor protocol specified the criteria for the diagnosis of labor, the timing and dose of oxytocin, and use of one-to-one nursing throughout the course of labor. Epidural analgesia was not part of the trial protocol but was administered to women in both groups upon request. Active management of labor did not alter the rate of cesarean delivery. A complete description of the study methodology and results has been published elsewhere.[16]

The current analysis included women from both the active management and usual care groups but was limited to women with singleton, term pregnancies with infants in a

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cephalic presentation and the spontaneous onset of labor resulting in live-born infants (n = 1303). Women were excluded if they were diabetic (n = 3) or had a herpes infection (n = 4), if maternal temperature was never recorded (n = 30), or if maternal temperature was elevated (>99.5°F) at admission (n = 31). Two women were also excluded because the birthweights of their infants were not recorded. After these exclusions, 1233 women remained.

All maternal temperatures recorded during labor were abstracted from medical records. Most maternal temperatures were assessed orally, and the few axillary temperatures were increased by 1° to adjust for differences in site of measurement. Maximum intrapartum temperature was initially classified into the following 4 categories: (1) no temperature elevation (99.5°F [37.5°C] or lower), (2) 99.6 to 100.4°F (37.6 to 38.0°C), (3) 100.5 to 101.0°F (38.1 to 38.4°C), and (4) higher than 101.0°F (38.4°C). Women in groups 2 through 4 were combined for some analyses and referred to as women with temperature elevation.

Rates of cesarean delivery and assisted vaginal delivery according to the presence of maternal temperature elevation were determined. Assisted vaginal delivery was defined as the use of forceps or vacuum. Indication for cesarean delivery was as recorded in the medical record. Crude rate ratios (RRs) and 95% confidence intervals (CIs) for the association of intrapartum temperature elevation with cesarean delivery were calculated. Because all comparisons were similar in the usual care and active management groups, the groups were combined to increase the precision of the study.

Most temperature elevation in our population occurred among women receiving epidural analgesia for pain relief. The association between temperature elevation and method of delivery was therefore investigated separately for women with and without epidural analgesia. We examined the rate of cesarean delivery overall and according to length of labor. We compared rates with the χ^2 test or the Fisher exact test, which was used when the expected value in any cell was less than 5.

Logistic regression analysis was used to examine associations, with control for confounding factors. Adjusted odds ratios (ORs) were calculated from the regression coefficients, and 95% confidence intervals (CIs) were calculated from the standard errors of these coefficients.

Results

Overall, 1233 women were included in the analysis, of whom 301 (24.4%) developed a temperature higher than 99.5°F after admission to the labor and delivery unit. Among the women with a temperature elevation, 175 had a maximum temperature of 99.6 to 100.4°F, 63 developed a fever of 100.5 to 101.0°F, and 63 developed a fever higher than 101.0°F. The characteristics of the study population according to maximum maternal intrapartum temperature are presented in Table 1. Women who developed a temperature higher than 99.5°F had somewhat larger babies and longer labors but were similar to women without temperature elevation with regard to age, race, insurance coverage, and the occurrence of premature rupture of the membranes.

The occurrence of neonatal infection was rare regardless of maternal temperature. There was only 1 infant with documented sepsis (maternal temperature of 102°F), and there were 3 babies with pneumonia (2 cases in which the maternal temperature was not elevated and 1 in which the maternal temperature was 100.5°F).

The rates of cesarean delivery and assisted vaginal delivery were higher for women whose maximum intrapartum temperature was elevated (Figure 1). The rate for cesarean delivery was 7.2% with a maximum temperature of no greater than 99.5°F, while the rate for women whose temperature rose above 99.5°F was 25.2% (RR = 3.5, 95% CI = 2.6, 4.7). Similarly, the rate for assisted vaginal delivery was 8.5% among women whose temperature remained at 99.5°F or lower but 25.2% among women whose temperature rose above 99.5°F (RR = 3.0, 95% CI = 2.2, 4.0).

In our term, low-risk population, the majority of cesarean deliveries were performed because of failure to progress; only 2% of women had cesarean deliveries because of fetal distress. This rate was similar

TABLE 1—Characteristics of Study Population According to Maximum Intrapartum Temperature: Brigham and Women's Hospital, Boston, Mass, 1990–1994

	≤99.5°F (n = 932)	99.6–100.4°F (n = 175)	100.5–101.0°F (n = 63)	>101.0°F (n = 63)	P[a]
Demographic characteristics					
Mean maternal age, y	30.2	30.5	30.2	30.1	.91
Welfare recipient, %	4.4	4.6	3.2	4.8	.97
Maternal race, %					.70
White	73.9	78.9	74.6	77.8	
Black	12.9	9.1	9.5	12.7	
Other	13.2	12.0	15.9	9.5	
Pregnancy and labor characteristics					
Mean birthweight, g	3402	3477	3536	3586	.0002
Length of labor, h, %					.001
0–6	37.0	4.6	4.8	4.8	
6–12	47.4	42.9	23.8	25.4	
12–18	12.8	37.7	38.1	38.1	
>18	2.8	14.9	33.3	31.8	
Premature rupture of membranes, %	18.0	21.7	25.4	17.5	.36
Treated with active management of labor, %	53.3	36.0	28.6	34.9	.001
Parenteral pain medication, %	64.3	61.7	68.3	55.6	.42
Epidural analgesia, %	49.8	85.1	96.8	98.4	.001

[a]From analysis of variance for comparisons of means and from χ^2 tests for comparisons of categorical variables.

regardless of the level of temperature elevation. In the group with assisted vaginal delivery, only 6 women (3.9%) carried a diagnosis of fetal distress; none of those women had an elevated temperature. Because the proportion of women with fetal distress was low, the associations we report between intrapartum temperature and method of delivery reflect differences in the rates of failure to progress, defined as either lack of progressive cervical dilatation or lack of descent of the fetal head.[17] In addition, because there was no monotonic trend in the occurrence of cesarean delivery or assisted vaginal delivery according to level of temperature elevation, all women whose temperature rose higher than 99.5°F were combined into a single group for the remaining analyses.

In our population of term, nulliparous women, almost all temperature elevation (90.4%) occurred among women who received epidural analgesia. Among women who received an epidural (n = 736), 37.0% developed an elevated temperature, as compared with 5.8% of women who did not receive an epidural (n = 497). We therefore examined the association separately among women who received and did not receive epidural analgesia. Intrapartum temperature elevation was associated with at least a 2-fold increase in the rate of cesarean and assisted vaginal delivery both with and without the use of epidural analgesia (Table 2).

Because fever is much more likely to occur with longer labors among women with epidural analgesia,[1] we examined the data to determine whether the increase in cesarean deliveries and assisted vaginal deliveries associated with fever might be the result of a longer length of labor among women developing an elevated temperature. We found that at each length of labor, women with an epidural and elevated temperature had a higher rate of cesarean delivery and assisted vaginal delivery than women with an epidural and a nonelevated temperature (Figure 2).

A logistic regression analysis was then performed to evaluate the association of intrapartum fever with cesarean delivery and assisted vaginal delivery after adjustment for the confounding effects of birthweight, treatment with active management of labor, epidural use, and length of labor. A temperature higher than 99.5°F was associated with a 2-fold increase in the risk of both cesarean delivery (OR = 2.2, 95% CI = 1.5, 3.4) and assisted vaginal delivery (OR = 2.1, 95% CI = 1.4, 3.1). In that regression, epidural remained a predictor of both cesarean delivery (OR = 2.0, 95% CI = 1.2, 3.4) and assisted vaginal delivery (OR = 3.9, 95% CI = 2.2, 6.7). These odds ratios represent the increased risk that remains after both the longer labors and the intrapartum temperature elevations consistently associated with epidural use have been taken into account.

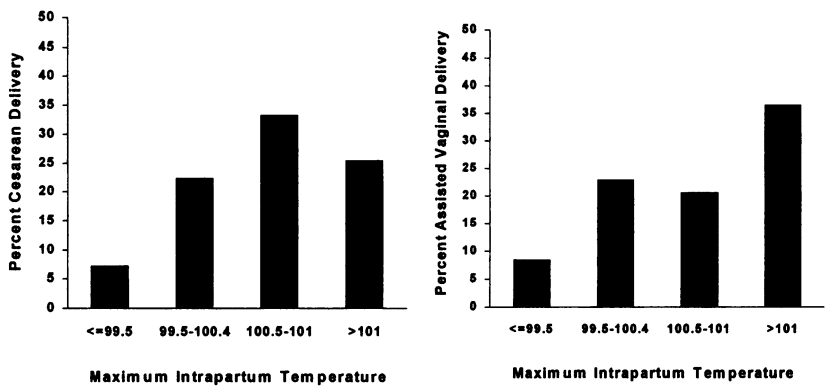

FIGURE 1—Method of delivery according to maximum maternal intrapartum temperature.

TABLE 2—Cesarean and Assisted Vaginal Deliveries According to Temperature Elevation and Epidural Use: Brigham and Women's Hospital, Boston, Mass, 1990–1994

	No Temperature Elevation	Temperature Elevation	Crude Rate Ratio (95% Confidence Interval)
Epidural			
No. of women	464	272	
Cesarean delivery, %	9.9	26.1	2.6 (1.9, 3.7)
Assisted vaginal delivery, %	14.0	26.5	1.9 (1.4, 2.6)
No epidural			
No. of women	468	29	
Cesarean delivery, %	4.5	17.2	4.6 (1.6, 13.1)
Assisted vaginal delivery, %	3.0	13.8	3.8 (1.6, 9.5)

Discussion

Our data suggest that modest temperature elevation developing during labor is a risk factor for cesarean and assisted vaginal delivery. Term, nulliparous women in spontaneous labor and afebrile at admission who developed a temperature higher than 99.5°F during labor were 3 times more likely to require a cesarean delivery (25.2% with temperature elevation, 7.2% without temperature elevation) or assisted vaginal delivery (25.2% with temperature elevation, 8.5% without temperature elevation). While 24.4% of women developed a temperature higher than 99.5°F, 53.1% of cesarean deliveries and 49.0% of assisted vaginal deliveries occurred in that group. In a multiple logistic regression analysis adjusted for potential confounding factors, including length of labor, women with an elevated temperature remained about twice as likely to require a cesarean delivery (adjusted OR = 2.2) or assisted vaginal delivery (adjusted OR = 2.1).

While 90.4% of women with elevated temperatures had received analgesia, the association of fever with both cesarean delivery and assisted vaginal delivery was present regardless of whether women received or did not receive epidural analgesia. The higher rate of fever associated with epidural use has been attributed to alterations in thermoregulatory functions,[2,5,18,19] a hypothesis supported by the increase in fever among women randomized in clinical trials to receive epidural analgesia.[12,20] In addition, in our population, women receiving epidural analgesia did not have a higher mean admission white blood count (no epidural: 13 500/$\mu L/mm^3$; epidural: 12 500/$\mu L/mm^3$), and admission temperature was similar (98.1°F) for the epidural and no epidural groups. This suggests that the excess cesarean and

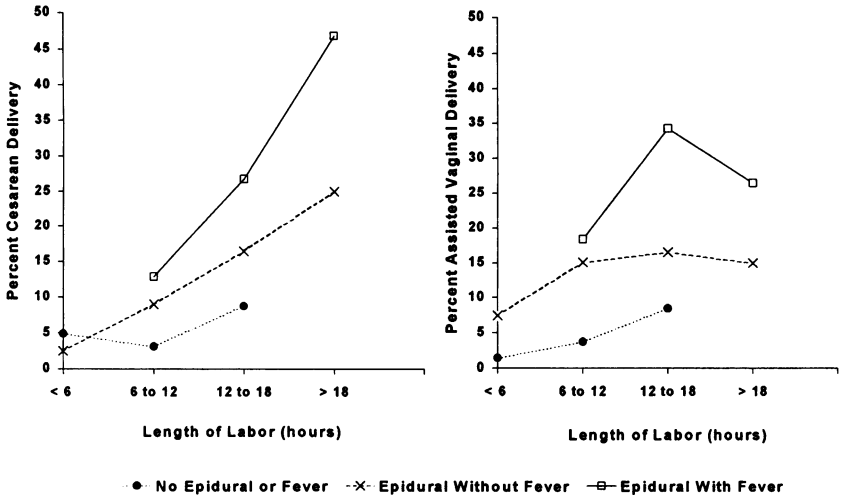

FIGURE 2—Method of delivery according to length of labor, intrapartum temperature elevation, and use of epidural analgesia.

assisted vaginal deliveries among women with an elevated temperature who received epidural analgesia were most often not related to the presence of infection. In contrast, intrapartum temperature elevation among women without an epidural may be more likely to be of infectious origin.

In our population of term, low-risk nulliparous women, both cesarean delivery and assisted vaginal delivery were largely related to failure to progress (defined as failure to dilate during the first stage of labor or failure of fetal descent during the second stage).[17] During the first stage of labor, failure to progress results in cesarean delivery. If failure to progress occurs during the second stage of labor, however, assisted vaginal delivery may sometimes be an alternative to cesarean delivery.

Chorioamnionitis has been reported as a risk factor for cesarean delivery[21–24] and, specifically, for failure to progress.[18] Given our finding that the rate of cesarean delivery is also higher with epidural-related fever (which is likely to most often be of a noninfectious origin), it may be that the increase in cesarean deliveries observed with chorioamnionitis is related to fever rather than to some other aspect of the infectious process. Because the manifestations of the febrile response may be uniform regardless of the initiating factor,[25] it is plausible that epidural analgesia can trigger at least some of the same physiologic events that occur with infection. For example, higher levels of serum interleukin-6 during labor have been reported among women receiving epidural analgesia.[26]

As with all studies, it is not possible to rule out residual confounding. However, for an unknown confounder to be responsible for the association we have observed, it would need to have an association with cesarean and assisted vaginal delivery at least as strong as the association between temperature elevation and cesarean delivery.

Since temperature elevation was much more common with epidural analgesia (37% with epidural, 6% without), the association of temperature elevation with cesarean delivery may be one reason for the higher rate of cesarean delivery observed with epidural use. Temperature elevation alone, however, does not completely explain the higher rates of cesarean delivery and assisted vaginal delivery observed among women receiving epidural analgesia. In the multiple logistic regression analysis we performed, epidural analgesia was still associated with about a 2-fold increase in cesarean delivery and an almost 4-fold increase in assisted vaginal delivery, even though the model controlled for both the longer length of labor and the elevated temperature that probably resulted from the use of an epidural.

Epidural analgesia is commonly used for pain relief during labor. A recent study indicates that in the United States, approximately 40% to 45% of women receive epidural analgesia for pain relief during labor.[27] That rate is likely to be higher among nulliparous women. Epidural use has been associated with higher rates of cesarean and assisted vaginal delivery in a number of studies. Our data suggest that the temperature elevation that is associated with epidural use may in part explain the higher rates of cesarean and assisted vaginal delivery. Given the widespread use of epidural analgesia, we believe that it is essential that further study be conducted to determine whether treatment or prevention of fever during labor represents a practical means of lowering rates of cesarean delivery and operative vaginal delivery. Such studies should examine both cesarean delivery and assisted vaginal delivery, because management of the second stage may vary across institutions and may change over time. □

Contributors

E. Lieberman supervised data collection, was significantly involved in all aspects of the study, including project design and data analysis, and was the primary author. A. Cohen was responsible for data management and performed all analyses; she also contributed to the project design and manuscript drafts. J. Lang participated in all aspects of design and analysis and critically reviewed manuscript drafts. F. Frigoletto served as principal investigator for the original project and contributed significantly to the design of the new project and the critical review of manuscript drafts. L. Goetzl collected data from medical records, participated in project design, and critically reviewed manuscript drafts.

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References

1. Lieberman E, Lang JM, Frigoletto F, Richardson DK, Ringer SA, Cohen A. Epidural analgesia, intrapartum fever, and neonatal sepsis evaluation. *Pediatrics*. 1997;99:415–419.
2. Fusi L, Maresh MJA, Steer PJ, Beard RW. Maternal pyrexia associated with the use of epidural analgesia in labour. *Lancet*. 1989;1:1250–1252.
3. Camann WR, Hortvet LA, Hughes N, Bader AM, Datta S. Maternal temperature regulation during extradural analgesia for labour. *Br J Anaesth*. 1991;67:565–568.
4. Vinson DC, Thomas R, Kiser T. Association between epidural analgesia during labor and fever. *J Fam Pract*. 1993;36:617–622.
5. Macaulay JH, Bond K, Steer PJ. Epidural analgesia in labor and fetal hyperthermia. *Obstet Gynecol*. 1992;80:665–669.
6. Herbst A, Wolner-Hanssen P, Ingemarsson I. Risk factors for fever in labor. *Obstet Gynecol*. 1995;86:790–794.
7. Lieberman E. Predictors of cesarean delivery. *Curr Probl Obstet Gynecol Fertil*. 1997;20:93–132.

8. Thorp JA, Breedlove G. Epidural analgesia in labor: an evaluation of risks and benefits. *Birth.* 1996;23:63–83.
9. Thorp JA, Parisi VM, Boylan PC, Johnston DA. The effect of continuous epidural analgesia on cesarean section for dystocia in nulliparous women. *Am J Obstet Gynecol.* 1989; 161:670–675.
10. Thorp JA, Eckert LO, Ang MS, Johnston DA, Peaceman AM, Parisi VM. Epidural analgesia and cesarean section for dystocia: risk factors in nulliparas. *Am J Perinatol.* 1991;8:402–410.
11. Thorp JA, Hu DH, Albin RM, et al. The effect of intrapartum epidural analgesia on nulliparous labor: a randomized, controlled, prospective trial. *Am J Obstet Gynecol.* 1993; 169:851–858.
12. Ramin SM, Gambling DR, Lucas MJ, Sharma SK, Sidawi JE, Leveno KJ. Randomized trial of epidural versus intravenous analgesia during labor. *Obstet Gynecol.* 1995;86:783–789.
13. Lieberman E, Lang JM, Cohen A, D'Agostino R Jr, Datta S, Frigoletto FD Jr. Association of epidural analgesia with cesarean section in nulliparous women. *Obstet Gynecol.* 1996;88: 993–1000.
14. Patterson CM, Saunders NSG, Wadsworth J. The characteristics of the second stage of labour in 25069 singleton deliveries in the North West Thames Health Region, 1988. *Br J Obstet Gynaecol.* 1995;99:377–380.
15. Hawkins JL, Hess KR, Kubicek MA, et al. A reevaluation of the association between instrument delivery and epidural analgesia. *Reg Anesth.* 1995;20:50–56.
16. Frigoletto FD, Lieberman E, Lang JM, et al. A clinical trial of active management of labor. *N Engl J Med.* 1995;333:745–750.
17. Cunningham FG, MacDonald PC, Gant NF, Leveno KJ, Gilstrap LC. Dystocia due to abnormalities of the expulsive forces. In: *Williams Obstetrics.* 19th ed. Norwalk, Conn: Appleton & Lange. 1993:475–491.
18. Mercier FJ, Benhamou D. Hyperthermia related to epidural analgesia during labor. *Int J Obstet Anesth.* 1997;6:19–24.
19. Macaulay JH, Randall NR, Bond K, Steer PJ. Continuous monitoring of fetal temperature by noninvasive probe and its relationship to maternal temperature, fetal heart rate, and cord arterial oxygen and pH. *Obstet Gynecol.* 1992; s79:469–474.
20. Sharma SK, Sidawi E, Ramin AM, Lucas MJ, Leveno KJ, Cunningham G. A randomized trial of epidural versus patient-controlled meperidine analgesia during labor. *Anesthesiology.* 1997;87:487–494.
21. Koh KS, Chan FH, Monfared AH, Ledger WJ, Paul RH. The changing perinatal and maternal outcome in chorioamnionitis. *Obstet Gynecol.* 1979;53:730–734.
22. Gibbs RS, Castillo MS, Rodgers PJ. Management of acute chorioamnionitis. *Am J Obstet Gynecol.* 1980;136:709.
23. Duff P, Sanders R, Gibbs RS. The course of labor in term patients with chorioamnionitis. *Am J Obstet Gynecol.* 1983;147:391–395.
24. Satin AJ, Maberry MC, Leveno KJ, Sherman ML, Kline DM. Chorioamnionitis: a harbinger of dystocia. *Obstet Gynecol.* 1992;79:913–915.
25. Saper CB, Breder CD. The neurologic basis of fever. *N Engl J Med.* 1994;330:1880–1886.
26. Jongh RF, Bosmans EP, Puylaert MJ, et al. The influence of anaesthetic techniques and type of delivery on peripartum serum interleukin-6 concentrations. *Acta Anaesthesiol Scand.* 1997;41:853–860.
27. Hawkins JL, Gibbs CP, Orleans M, Martin-Salvaj G, Beaty B. Obstetric anesthesia work force survey, 1981 versus 1992. *Anesthesiology.* 1997;87:135–143.